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EDITORIAL

GOODWILL, PEACE, PLENTY

MAN does not live by bread alone, but he cannot live without it. Good food begets health of body and mind and good friendship amongst neighbours. It is difficult to provoke a quarrel with a man who has lunched well and whose stomach is still experiencing those inward joys which can be induced in his patrons by a master of the culinary art. No doubt this is one of the reasons why Christmas is one of the occasions when the spirit of amity reigns. The founders of the Christian religion were astute psychologists when they encouraged the cult of the festive board to be associated with and coincide with the great religious festivals of the year.

During the last decade we have heard much about food. We have been told by great authorities that the world was in dire peril of famine and starvation and this in spite of the fact that the earth, stimulated to great productivity by the demands of a world war, was giving of her fruits in greater amount than ever before. The doleful pedlars of misery seemed to take no account of the major factors which led to faulty distribution and consequent shortages in some areas whilst in others there was repletion. These factors are manpower problems, transport and monetary exchange, all made of man and not of nature.

If there is no means of getting one's groceries home it is futile to go to market; on the other hand, if the means and methods of exchange cannot be agreed between purchaser and vendor a visit to the market can be equally exasperating and a plethora of transport is of little value.

(The November issue of The British Veterinary Journal was published on November 4)

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For many years past the good earth has been producing sufficient to provide for all the needs of its men and animals and there are great areas of potentially productive land still untapped which can be harnessed to provide the means of life for many years to come, even if the population continues to increase in numbers.

At the present time there is a surplus of some of the essential foods, especially of cereals. In the great corn-growing areas this is the cause of serious embarrassment, for it is reported that some store houses have not been cleared of the 1954 crop and some of the 1955 harvest, perforce, has to be stored in the open.

This state of affairs is tragic when there are people and animals in other parts of the world suffering from malnutrition. Manpower on the land is another problem in spite of mechanisation. In the areas where production is at a high level there is a shortage, and in places where production is low there is often a surplus of men.

Good transport facilities mean that food can be diverted to necessitous areas. It also means that one can exercise choice in the matter of the crops and animals to be grown and agriculture can be selective according to the prevailing environmental conditions. Shipping is the key to good distribution, and for many years the shortage of vessels has been serious owing to the losses during the recent world war.

For instance, we in this country could not take full advantage of the meat and other animal products available in New Zealand because there were not enough suitbly-equipped boats to make a continuous and efficient turn-round.

The shortage of manpower on the farms is, to a great extent, dependent upon good-will and confidence between men and nations. In the absence of amity then each and all become suspicious of their neighbours and look to their defence against attack. The industries concerned with defence measures thrive and they make prodigious demands on manpower. Great forces are collected in the armed services and equally large numbers of men and women are employed to keep them in supplies.

These are amongst the principal reasons why the peoples of the great nations cannot devote their complete attention to the advancement of mankind and why poverty and malnutrition continue to exist in many parts of the world.

In 1955 the Geneva Conference of the heads of the most powerful states brought a great ray of hope to a sorely troubled world. It may be that those hopes were set too high, for the recent meeting of foreign ministers has disappointed us all. We must not despair, for whilst the opposing forces are prepared to meet and talk it is unlikely that there will be recourse to arms. It may be that the more they meet the more will the spirits of good-will and amity, which are the very essence of the Christmas spirit, prevail and mistrust, fear and selfishness be banished for ever.

As we approach this Christmastide let us hope and pray that the spirit of fellowship and good cheer will break its customary bounds and pervade amongst the community of nations.

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GENERAL ARTICLES

AN OUTBREAK OF OVINE CONTAGIOUS OPHTHALMIA TREATED WITH CHLORAMPHENICOL

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CONTAGIOUS OPHTHALMIA, or heather blindness as it is sometimes called, is not uncommon amongst sheep in Great Britain. It is associated with the presence in the conjunctival epithelium of inclusion bodies which Coles (1931*a*) had named *Rickettsia conjunctivæ*. Blakemore (1947), however, pointed out that the infectious agent does not entirely conform to the definition of the Rickettsiæ, and Rake (1948) has proposed that it be renamed *Colesiota conjunctivæ*. Outbreaks vary in severity and may occur throughout the year although spring and autumn are probably peak periods. Sheep of all ages and either sex may be affected, but outbreaks are more frequent amongst lambs. The earliest symptom is a profuse watery discharge from the affected eye, the conjunctiva being œdematous and the sclera injected. In mild cases the condition may progress no further, recovery commencing within a few days, while in more severe cases a keratitis supervenes with varying degrees of corneal opacity. It has been shown by Beveridge (1942) that animals which have recovered from the disease are carriers and are responsible for the persistence of infection in a flock. The disease may be transmitted artificially and readily by the transfer of conjunctival discharges from an infected to susceptible sheep. Natural transmission probably takes place by droplet infection, the infective agent passing along the lachrymal ducts. Beveridge (1942), however, drew attention to the seasonal nature of the disease and suggested that an arthropod vector may be involved.

History

The outbreak of contagious ophthalmia described below occurred in sheep kept on the commercial farm of the University College of Wales, Aberystwyth, in February, 1955. The flock comprised 61 Clun forest ewes, 6 Welsh mountain ewes, and 3 Clun rams. The ages varied from one to seven years, the majority being over two years old. Rotational grazing was employed and during January and February the flock received a supplementary ration of concentrates and a mineral mixture. On the afternoon of February 5 the rams were put on an outlying grazing and the ewes were taken into a Dutch barn, preparatory to lambing, in which bales of hay were used to make a fold. The ewes spent the nights of February 6 and 7 in the fold and on the next day the farm manager decided to divide them into two groups, A and B. Group A comprised 26 ewes approaching lambing; these were put out during the day, returning to the fold at night. Group B included the remainder of the ewes, which were out both day and night. The two groups grazed different pastures.

On the afternoon of February 6, before the ewes were divided, one ewe was noticed to be showing symptoms of blindness and on the following day the

shepherd, believing it to be the result of an injury, treated the condition by blowing sugar into the eye. On the following Tuesday, when the ewes were being divided, 22 were showing symptoms of conjunctivitis, as also was a lamb born on February 5. At this stage professional assistance was sought, and a diagnosis of contagious ophthalmia made by Mr. W. M. Jones, M.R.C.V.S. I am indebted to Mr. Jones, who kindly brought the outbreak to my notice, as a result of which the following observations were made.

Observations on the Flock

When I examined the flock on Thursday, February 10, all but 12 ewes were affected in one or both eyes. As lambing progressed, the new-born lambs began to show symptoms generally when 48 hours old, but in three cases 24 hours after birth. The main bulk of the lambs did not begin to arrive until February 20, and by this time many of the ewes had recovered, only the worst cases remaining.

Up to February 20 all new-born lambs developed conjunctivitis, but after this date the incidence began to fall. It was noticed that the severity of the condition in the ewe appeared to play no part in determining whether or not the lamb became affected. The condition lingered amongst the flock for lambs born in the latter part of March developed symptoms.

In the early stages of the disease there was a watery discharge from one or both eyes and photophobia was apparent. The conjunctiva was œdematous and hyperæmic, with a tendency to bulge over the cornea. In lambs, the eyelids were swollen, but this was not so marked in adult sheep. The vessels of the sclera were prominent and in some cases there was vascularisation of the cornea. More-advanced cases showed varying degrees of keratitis with corneal opacity, the opacity commencing at the periphery, giving a bluish border to the cornea. Later the opacity became complete and was followed by pannus formation, and, in two cases, corneal ulceration was noted. Several ewes affected in both eyes were completely blind and one of these fell into a ditch and was drowned.

Scrapings of the conjunctiva from a number of ewes were stained by Macchiavello's method and the inclusion bodies described by Coles (1931*a*) were demonstrated without difficulty. An unsuccessful attempt was made to infect rabbits by instillation into the eye of conjunctival discharges from an infected sheep.

Treatment

Most of the common ophthalmic lotions and ointments have been recommended for the treatment of contagious ophthalmia, but due to the variation in the severity of the condition, critical evaluation of their efficacy is difficult. Beveridge (1942) reported that concentrated zinc sulphate sometimes clears the eye of inclusion bodies. Michael (1953) thought that oral administration of riboflavin was beneficial, and Riley and Barner (1953) stated that chloramphenicol was effective. In the present outbreak, the first twenty ewes to become affected

were treated with applications of 1 per cent sulphacetamide ophthalmic ointment twice daily. In subsequent cases, chloramphenicol was employed, at first in the form of a 1 per cent ointment and later as an 0.5 per cent aqueous solution.

On February 10 the whole flock, except the 20 ewes being treated with sulphacetamide, were started on a 14-day course consisting of twice-daily instillations into each eye of two drops of 0.5 per cent chloramphenicol solution. All young lambs becoming affected were treated similarly with chloramphenicol.

Conjunctival scrapings were examined from three of the twelve ewes free from clinical symptoms on February 10, and in each case inclusion bodies were present. Morphologically they were indistinguishable from those seen in scrapings from affected eyes, although Coles (1931*b*) has described non-pathogenic cell inclusions in the conjunctivæ of normal sheep. It was decided to include these 12 animals in the treatment with chloramphenicol. Nine subsequently became mildly affected, two developed corneal opacity in one eye, and the other appeared to remain free from the disease.

By February 13, ten of the ewes being treated with sulphacetamide had severe keratitis in one or both eyes. The farm manager, impressed by the fact that no advanced lesions had so far occurred in the chloramphenicol-treated group, pressed for its use throughout the flock. Accordingly, the 20 ewes previously treated with sulphacetamide ointment were started on a course of chloramphenicol drops.

Conjunctival scrapings from 12 mild cases were examined before and after 14 days of treatment with chloramphenicol. Inclusion bodies were plentiful on both occasions.

It is not possible to draw definite conclusions about the effectiveness of chloramphenicol as used in the present outbreak, because of the absence of controls. The results suggested that early use of the drug was of value in reducing the incidence of keratitis. As the chloramphenicol did not rid the conjunctival epithelium of inclusion bodies, this may indicate that secondary bacterial invasion is involved in the advanced stages of contagious ophthalmia. When the drug was used in the treatment of established cases of keratitis, it seemed to accelerate recovery. The treatment of young lambs gave the best results, but observations in the present instance agree with those of Beveridge (1942) in that the disease is of a milder nature in young animals.

Riley and Barner (1953) used an ointment containing approximately 5 per cent chloramphenicol and the frequency and duration of treatment was less than in the present trial. These authors reported satisfactory results but did not state whether the drug had freed the conjunctiva of inclusion bodies. On economic grounds, however, it is doubtful if the wholesale treatment of outbreaks in commercial flocks could be justified.

Discussion

In the outbreak described, the history of the flock was known, and it is of interest to speculate how the infection gained access to the farm. Beveridge (1942) has shown that it is possible to infect susceptible sheep from carriers 257 days

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after the recovery of the latter, but it is believed that, in this outbreak, the flock had not been in contact with the disease for a period of at least two years. The severity of the outbreak also suggests that immunity was low.

No other farms in the vicinity were affected, as far as could be ascertained, although the condition has been known in the area. Blakemore (1947) found that solid divisions four feet high were sufficient to prevent spread between groups of experimental animals. In a natural outbreak, however, spread from carriers in other flocks by human, animal or physical means cannot be excluded. Under experimental conditions, Blakemore (1947) found the incubation period to be regularly 48 hours, but in the present outbreak, symptoms were seen in three new-born lambs 24 hours old. There seems to be little doubt that the infective agent was a virulent variety and in new-born lambs the incubation period may be shorter.

Since the first case was not observed until shortly after the flock were confined to the barn, the possibility of this being the source of infection must be considered. The fact that the rams did not become affected lends support to the theory. Similarly, if infection was present prior to the flock being put into the barn, trough feeding would seem to provide a fair environment for its spread. It is appreciated that housing involved crowding and dust, but on the other hand the sheep had been housed previously for weighing, blood and fæces sampling, although not for long periods and not in the barn. Inclement weather has been regarded by some authors as a predisposing factor, but during January extreme conditions did not occur, the latter part of the month being mild. No snow fell until after the onset of the outbreak.

The sheep did not have access to hay until they were put into the barn. The hay had come from the Eastern counties of England and was the first to be bought for a long time. It is well known that foot and mouth virus can remain alive for many months in hay and it is not impossible that the infective agent of contagious ophthalmia may also survive.

The incidence of the disease in new-born lambs proved interesting. As time went on the number becoming affected grew less, even though inclusion bodies could still be demonstrated in the conjunctival cells of the ewes. It is assumed that the infective agent was losing its virulence and the ewes were passing on immunity to their lambs.

The importance of the disease has been attributed to the loss of condition following failure to eat due to blindness. In the present outbreak, however, only one Welsh ewe showed any loss of weight. Other ewes, even those completely blind, continued to do well and went on to produce and rear strong lambs. The only mortality in the present outbreak was the ewe which was drowned, but in flocks not under careful supervision during the disease, losses of this kind are probably more important. In no case did permanent damage to the eye result.

Summary

An outbreak of contagious opthalmia in a flock of 70 sheep is described.

Treatment with 0.5 per cent aqueous solution of chloramphenicol applied twice daily for 14 days resulted in an apparent reduction in the number of cases

developing keratitis. The drug did not clear the conjunctival epithelium of inclusion bodies.

The possible sources of infection are discussed and the suggestion is made that hay imported on to the farm may have been involved.

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STUDIES ON HÆMORRHAGIC SEPTICÆMIA OF CATTLE

V. Tests for Immunity in Vaccinated Cattle*

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ALTHOUGH the ultimate test for immunity is exposure to infection, it is desirable to have other tests which can give information in the early stages of an experiment. The tests described in this paper were developed on a group of vaccinated cattle in Australia and applied to a small group in Thailand which were then challenged. All the cattle in this series had received formalin-killed vaccines either as plain bacterins or as oil-adjuvant vaccines. All tests were conducted with the "Insein" strain of *Pasteurella multocida* type I.

Agglutination

A simple agglutination test for the detection of animals with naturally-acquired immunity was described by Bain (1954). There have been no reasons to doubt the efficacy of the test when it is used for this purpose. However, when applied to vaccinated animals it commonly fails to indicate all those which prove immune to direct challenge. In Table I there is shown the results of the agglutination test and challenge on 20 buffaloes. These are drawn from the results of some 200 animals and are quite typical. The results in cattle are similar.

One feature is that in no instance did an animal with a ++++ or +++ reaction succumb to challenge. The difficulty arose from the unpredictable immune status of animals with lower reactions. This suggested that blocking

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antibodies were present. Tests were made for the inhibiting effect of suspected sera on sera inducing normal agglutination. The technique employed was to add to weakly-reacting tests a dose of a "normally-agglutinating serum" just sufficient to bring about agglutination of the bacteria in normal circumstances, i.e., in the

TABLE I

Result of Agglutination Test and Challenge in Water Buffaloes.

Buffalo No.	Vaccine	Agglutination	Challenge
63	Live Attenuated	++++	Survived
56	Plain Bacterin	++++	"
96	Oil Adjuvant	++++	"
83	Oil Adjuvant	++++	"
106	Live Attenuated	+++	"
59	Plain Bacterin	+++	"
58	Oil Adjuvant	+++	"
45	Oil Adjuvant	+++	"
53	Live Attenuated	++$\frac{1}{2}$	"
111	Plain Bacterin	++$\frac{1}{2}$	"
116	Oil Adjuvant	++$\frac{1}{2}$	"
125	Live Attenuated	++	Died
106	Live Attenuated	++	Survived
52	Plain Bacterin	++	Died
61	Plain Bacterin	++	Died
84	Plain Bacterin	++	Survived
93	Oil Adjuvant	++	Died
105	Oil Adjuvant	++	Survived
128	Plain Bacterin	+	Survived
60	Live Attenuated.	+	Died

TABLE II

Agglutination and Blocking Antibody Tests in Buffaloes

Buffalo No.	Agglutination	Blocking Antibody	Buffalo No.	Agglutination	Blocking Antibody
5	+	-	15	+	-
12	+	-	17	+	-
14	-	++	20	-	++

Nos. 5 and 12 unvaccinated. No. 15 immune to challenge. Others not yet challenged. No. 14 gave strong C.F. test.

++ = 50% inhibition of the normally agglutinating serum.

absence of blocking antibody. The results in some animals in Thailand are shown in Table II.

For testing the sera from the Australian cattle, an anti-bovine gamma-globulin serum was prepared in rabbits. The globulin was prepared by the

Fig. I. Buffalo showing immune local reaction to challenge.

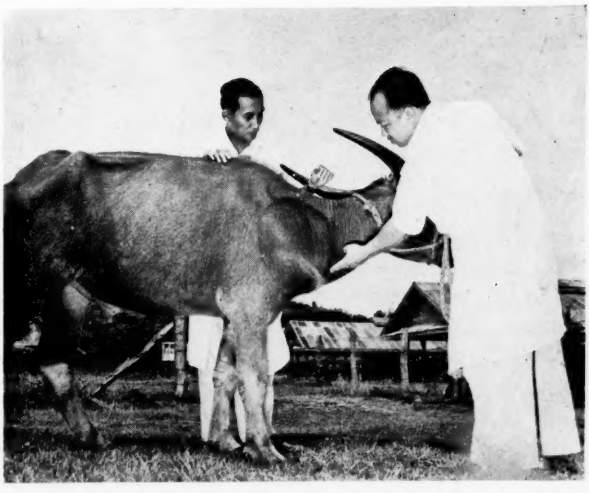

Fig. II. Partially immune reaction. No bacteræmia.

(Article by Bain, page 511)

ethanol fractionation methods of Cohn. Agglutination tests using 2 ml. of serum were carried out on the cattle sera. From those showing low reactions the supernatants were removed, centrifuged, the bacteria were recovered, washed once in saline and resuspended in 0.9 per cent carbol saline to the original volume. Controls were prepared from bacteria suspended in normal sera. To each tube was added 0.5 ml. antiglobulin serum and the tests were incubated overnight at 37° C. Results of the direct agglutination, blocking antibody and mouse protection tests are shown in Table III.

TABLE III

Agglutination, Blocking Antibody and Mouse Protection in Sera of Vaccinated Cattle.

No.	Agglutination	Blocking Antibody	Mouse Protection
219	+	++	4/4
216	++	+	1/4
115*	++	++	0/4
316	++	+	4/4
314	++	-	2/4
304	+	-	1/4

Blocking Antibody ++ = 50% agglutination in anti-globulin serum.
Numerator = Survivors. Denominator = Number injected.
* This animal showed mouse protective antibody at the next monthly test.

From these results it appears that though blocking antibodies occur and can be detected, the tests employed do not provide results which explain all low agglutination reactions. A search for a different type of agglutinating suspension which would give sharper results has so far been unsuccessful.

The single-tube agglutination test is useful on vaccinated animals in that strong reactors can be safely regarded as immune. Weak reactors may be either immune or susceptible. Illustrative of this is a vaccination experiment in Thailand in which 49 water buffaloes were challenged with 25,000 L.D. five weeks after vaccination. Of 21 strong reactors none died; of 28 weak reactors (++ or less) 10 died.

Agar Agglutination Test

This arose from attempts to find whether immune serum incorporated in agar was inhibitory to the growth of *P. multocida* type I. The procedure finally adopted is to add 1 ml. of test serum to 12 ml. melted tryptose agar at 45° C., mix, and pour immediately into a three-inch Petri dish. After setting, each plate is seeded with 0.25 ml. of a six-hour " Phase I " broth culture, which is spread with a bent glass rod. Incubation at 37° C. is carried out for 20 hours and attempts then made to wash off the surface growth with 2.5 ml. normal saline. Controls are medium without serum and medium plus normal serum. No mechanical aids such as beads are used.

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Growth occurs all over the plate even when hyperimmune serum is used, though with strongly-reacting sera it is thinner and harder in appearance. Growth of this type cannot be freed from the agar by washing, and the saline remains clear; this is called +++. The control plates should wash smoothly and easily with a little gentle agitation. In between are found a range of reactions with more or less growth coming up into the saline. When examined with a hand magnifying glass the bacteria in the saline are found to be agglutinating and the degree of agglutination is awarded + or ++. In the latter case there is still much adherence to the agar.

TABLE IV

Comparison of Agar Agglutination and Mouse Protection in Sera of Vaccinated Cattle

Animal No.	Agar Agglutination	Mouse Protection	Animal No.	Agar Agglutination	Mouse Protection
210	+++	7/8	209	+	2/8
221	+++	8/8	423	++	0/8
302	++	8/8	306	±	2/8
201	+++	3/8	308	-	5/8
703	+++	1/8	303	-	-
213	+	6/8	314	-	-

Numerator = Survivors. Denominator = Number injected.

This test has been persevered with as it would be useful under simple conditions if reliable. In Table IV are shown the representative serum reactions of 12 Australian cattle tested six months after vaccination. There were 36 cattle tested at this time; 31 showed correlation between agar agglutination and mouse protective capacity of the serum; three showed no correlation and in two there was mouse protection but only very slight agar agglutination.

In Table VII, the results on 12 cattle challenged in Thailand, there is correlation between agar agglutination, mouse protection and survival to challenge. The quantitative correlation is not particularly good in that the results in mice could not be predicted accurately from the results on agar.

Mouse Protection Test

Mouse protective antibodies have been detected in the sera of cattle for up to 12 months after vaccination with 3 ml. of oil-adjuvant vaccine. The test in its present form in this laboratory consists of the injection subcutaneously of 0.5 ml. of serum into mice, followed by intraperitoneal challenge with 10 $L.D._{50}$ of virulent six-hour broth culture 24 hours later. Deaths occur up to the third day after challenge but very rarely after that. Counts are made on the third day. The "Insein" strain usually has an $L.D._{50}$ of 0.1 ml. 10^{-10} saline dilution of this culture. The mice should be challenged soon after the dilution is prepared. The argument for using this particular challenge dose is that it is the smallest which kills all controls regularly. The effect of varying the challenge dose is shown in Table V.

The results of serological tests and challenge of 12 cattle in Thailand are shown in Table VII. Because few mice were available only two could be spared for each test; usually four are used. All the vaccinated animals survived challenge and all showed mouse protective antibodies in their sera.

Thirty-six normal cattle were tested in Australia. None showed mouse protective capacity against 10 L.D.$_{50}$ of "Insein."

TABLE V

Mouse Protection Test: Effect of Challenging Dose on Survival

Cattle Sera	10 LD 50	1,000 LD 50	100,000 LD 50	10,000,000LD 50
307	4	4	3	2
319	4	4	4	3
221	4	4	2	1
219	4	4	2	1
703	4	2	2	0
216	2	2	2	0
22	4	4	0	0
309	4	4	3	4
112	2	2	0	0
305	4	3	4	2
211	2	2	0	0
TOTALS:	38/44	35/44	22/44	13/44
CONTROLS:	0	0	0	0

Numbers = Survivors
4 mice in each group

In a test on 20 vaccinated cattle in Burma, pairs of mice received 0.5 ml. serum each but were challenged with 50,000 L.D., the same challenge used on cattle. Fourteen cattle survived and five of these showed mouse protective antibody. The sera from the six cattle which died did not protect mice.

No false positive result has been obtained on any animal challenged and at present the test is regarded as the best presumptive indication of immunity in vaccinated animals. No attempts have yet been made to refine the test to the form used by Meyer and Foster (1948) for *P. pestis*.

Complement Fixation

Complement-fixation antibodies have been demonstrated in titres of from 1 :4 to 1 :16 on the sera of some vaccinated animals. These antibodies have only been found in sera which protect mice though the converse is not true and some strongly-protective sera do not show these antibodies. The standard test is to use 2 M.H.D. of guinea pig complement, formalin-killed bacteria grown in tryptose broth and resuspended in saline as antigen, and to allow fixation to proceed for

one hour at 37° C. before adding the sensitised sheep red cells. The density of the antigen suspension is 2 on the Burroughs Wellcome scale. Equal volumes of each reagent are used. Results are read after 20 minutes' incubation with the red cells.

Some typical results are shown in Table VI.

TABLE VI

Complement Fixation and Mouse Protection Tests in Vaccinated Cattle

Animal No.	C. F. Titre	Surviving Mice
210	+++ at 1:8	7/8
311	+ at 1:16	6/8
221	—	8/8
302	+ at 1:16	8/8
201	+++ at 1:16	3/8
319	+++ at 1:16	7/8
307	· —	8/8
308	—	5/8
310	++ at 1:16	7/8
115	+++ at 1:16	3/8

TABLE VII

Comparison of Indirect Tests for Immunity with Results of Challenge.

Animal No.	Agglutination	Blocking Antibody	Agar Agglutination	Complement Fixation.	Mouse Protection	Challenge
207	+	Trace	+	++	+	Survived
195	+++±		+++	–	++	"
91	+++		+	Trace	++	"
49	++++		+++	Trace	++	"
206	++	Trace	+	–	+	"
93	+	–	++	Trace	++	"
61	++±		+	+	++	"
179	++++		+++	–	++	"
190	+	–	++	–	+	"
143	+	–	++	–	+	"
Control 1	+	–	–	–	–	Died
Control 2	++	–	–	–	–	Died

Complement fixation tested at 1:4 serum dilution only.

Mouse Protection: each + = survival of a mouse. Only 2 mice for each serum.

Blocking Antibody: Tested by inhibition of a normally agglutinating serum.

An unexplained feature is that complement-fixation antibodies are found more commonly in animals receiving agar-grown vaccine. All the animals in Table VI received this type of vaccine, with the exception of No. 310 which had a double dose of broth-grown vaccine. In this experiment 8/10 agar-vaccinated

and 3/26 broth-vaccinated cattle showed complement-fixation antibodies. In Thailand 8/10 buffaloes (agar vaccine) showed antibodies, and 0/5 receiving an attenuated live vaccine though the latter were immune to challenge a month later.

Comparison of Tests with Challenge

A group of 12 vaccinated cattle in Thailand have been tested by these methods and then challenged with 1,000 L.D. of six-hour broth culture of "Insein" subcutaneously. Five and a half months previously they had received 3 ml. of formol-killed agar-grown oil-adjuvant vaccine. Results appear in Table VII.

These tests suggest that the mouse protection and agar agglutination tests merit attention as indicators of immunity in vaccinated animals. The mouse-protection test should be the better of the two as it measures circulating protective antibodies in the animal. Results in Table IV show that the two tests do not always coincide. In one animal in Australia, No. 308, the agar agglutination test has been consistently negative over four repeated monthly tests whilst the serum has always been mouse protective. The advantage of the agar test is that it can be used where there is no mouse colony with expectation of fairly reliable results.

In their present form the single-tube agglutination test, the complement-fixation test and the blocking antibody test are only partially helpful. False positives have not occurred but immune animals have been missed.

Selection of a challenging dose for cattle is largely arbitrary. At present a 1,000 L.D. dose has been settled on. At various times doses of from 5 L.D. to 50,000 L.D. have been used on animals vaccinated from one to six months previously. Because of many variable factors in the tests, such as differing vaccines, doses, breeds and species of animals, it has not been possible to extract good experimental data on the point. The subjective impression has been that within reason the challenging dose doesn't matter very much. At the higher level of 50,000 L.D. a few animals have relapsed after appearing to withstand challenge and a few have shown partially-immune reactions with delayed death. These animals may have withstood a lower challenge. This is why 1,000 L.D. is used now. This dose also leaves a margin for any minor errors in preparing or injecting the culture dilution.

The middle of the side of the neck is a suitable site for injection, as a clear picture is obtained of the local reaction. In immune animals, 4 to 18 hours after injection a crisply-outlined swelling 2 to 3 inches in diameter is visible. The swelling rarely goes beyond these limits. In water buffalo the character of this swelling, coupled with the temperature reaction, enables the fate of the animal to be predicted the morning after challenge (i.e., at the 18th hour) with over 90 per cent accuracy. In susceptible animals the swelling is diffuse and hot, without a sharply-outlined edge; it extends rapidly to the brisket. In water buffalo there is a persistently elevated temperature from 104° to 106° F. A few

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animals show an intermediate reaction. The swelling remains circumscribed but increases in size. They may develop a bacteræmia and die or the infection may remain localised, followed by recovery. These animals are classed as partial immunes. Unfortunately, all have been encountered before the tests described in this paper were developed.

Cattle do not always react in such a characteristic manner but in most cases the swellings are present. In susceptible animals the temperature rise may be quite brief and unless temperatures are taken six hours after challenge it may be missed; thereafter it is most commonly within normal limits until death about 30 hours later.

Discussion

The mechanism of immunity to hæmorrhagic septicæmia of cattle is not properly understood. The similarity of *P. multocida* type I to *P. pestis* suggests that the same mechanisms may operate as in human plague. These have been well reviewed by Meyer (1950). In immunity to plague, mouse protective antibodies are highly significant. Cellular factors are also important. In vaccination experiments against hæmorrhagic septicæmia in the laboratory, the animals are usually in good health. Under natural conditions the disease usually occurs in animals which are stressed by the heavy rains following a prolonged dry period in which fodder is scarce. It is possible that in these animals immunity may fail in the presence of circulating antibody because of ineffectiveness of the cellular mechanisms. Until proved by actual field trials, vaccines which give satisfactory results to the tests described in this paper can be regarded as potentially good only.

Summary

The mouse protective test is the best indication of immunity in vaccinated cattle. An agar agglutination test, which is simple, gives fairly good results. The agglutination and complement fixation tests in their present forms are less satisfactory.

Acknowledgments

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SOME OBSERVATIONS ON ANTHELMINTIC DOSING OF HILL HOGGS IN SOUTHERN SCOTLAND

By I. W. PARNELL and A. M. DUNN

With a Statistical Appendix

By E. C. R. REEVE

Introduction

THE successful control of braxy and louping-ill means that "black-scours," caused by heavy infestations of *Osteragia* spp. and of *Trichostrongylus* spp., is now the major cause of death in Scottish hill hoggs; moreover, this disease renders many hoggs that survive unfit to breed as gimmers and, in fact, they may never become satisfactory breeding ewes. On the hill, especially in severe winters, it may be impracticable and economically unsound to prevent hoggs losing weight by giving extra feeding, and if hoggs suffer from malnutrition, helminth infestations are always heavy. However, it is not always clear how far the infestation is the result of and how far it is the cause of malnutrition. Other adverse factors also predispose to helminthiasis.

Observations on hoggs wintered on the hill in the southern half of Scotland have shown that on most farms the worm egg counts fall somewhat during the late autumn, start to rise about the middle of the winter, and continue to rise until late in the spring (Morgan and Sloan, 1947; Morgan, Parnell and Rayski, 1950).

The object of the dosing trials was to study the effect of dosing at those times, which were believed to be critical, on worm burdens and subsequent changes in body and fleece weights.

For this reason one or two doses were given in the autumn, when *Ostertagia* spp., *Trichostrongylus* spp., some *Bunostomum trigocephalum* and occasionally *Hæmonchus contortus* are the main species parasitising hoggs (Morgan, *et al.*, 1951, 1952; Parnell, *et al.*, 1954 *a* and *b*; Parnell, 1954).

Most of the trials included a drenching in early winter, because by then the feeding value of hill pastures is very low, and it was considered that, although the infestations might be comparatively light at that time, their removal would help the hoggs.

In all the trials the hoggs were dosed again in late winter or early spring to reduce the infestations, which start to increase in February, and which include *Chabertia ovina* and *Œsophagostomum venulosum,* in addition to *Ostertagia* spp., *Trichostrongylus* spp. and *B. trigonocephalum.* Some of these drenchings were early in March, with the purpose of preventing damage during that month, which is so critical for hill sheep; in other trials the hoggs were dosed a few weeks later, with the object of reducing the worm burdens when they were heavier.

Some of the spring infestations are probably caused by larvæ which have survived on the grass since the previous autumn. Infective larvæ of the bursate nematodes of sheep have been found on grass throughout the winter on Scottish

hills, even when the ground was frozen hard and had been so for several weeks (Morgan, *et al.*, 1951). The eggs and the infective larvæ of some of the species, which infest Scottish hill sheep, are known to possess considerable resistance to cold, especially *Nematodirus* spp. and *Ostertagia* spp. (Griffiths, 1937; Swales, 1940; Shorb, 1942; Kates, 1943, 1950; and many others). A severe winter may, in fact, favour some species, especially when snow lies, and by lowering the condition of the sheep may reduce their resistance to the larvæ they ingest.

Gordon (1953*b*) in a bioclimograph based on the average rainfall and mean monthly maximum temperature at Eskdalemuir, Dumfriesshire, shows that the favourable conditions for the development of the free-living stages of *Trichostrongylus* spp. and of *Ostertagia* spp. last from about the middle of April until the end of September, except for some weeks in June and July. Crofton (1949) has shown that the numbers of infective larvæ on the grass of hills in Northumberland are greatest towards the end of August, when stocking on most hills has reached its peak.

Therefore, throughout the period of all these trials the hoggs were undoubtedly subject to some reinfestation.

The important consideration, however, is the numbers of larvæ which are able to develop either partially or completely in the host; these numbers are greatest from mid-winter until spring (Morgan, *et al.*, 1951, 1952; Wilson, *et al.*, 1953; Parnell, *et al.*, 1954*a*; Parnell, 1954); the extent of this increase is probably not entirely dependent on the numbers of larvæ which are ingested.

Infestations of *H. contortus* increase later than those of most other species; this suggests that larvæ of this species may seldom over-winter on Scottish hills, which is consistent with the known temperature requirements of the free-living stages (Veglia, 1915), although Kates (1943) and Shorb (1944) have shown that a few larvæ of this species can survive the rigours of winter in Maryland.

Material and Methods

Types of Trial.

Dosing trials on hill sheep must suffer from one of two unavoidable difficulties in assessing the results. If two or more hefts* are used and the sheep of one heft are left as the undosed controls, and the sheep of the other heft, or hefts, are dosed, then the difficulty arises that no two hefts are identical. The alternative is to dose some of the sheep of a heft or hefts and to leave the other sheep undosed as the controls, but this has the objection that the undosed sheep may continue to contaminate the grazing with large numbers of nematode eggs, which may reduce the effect of dosing (see Appendix).

Most of the earlier anthelmintic dosing trials on sheep wintered on the hill were carried out by dosing all the sheep of a heft; the sheep of an adjoining heft, on which other observations were being made, were used as controls.

In the latter trials half or two-thirds of the hoggs were dosed; after being divided by their body size into two or three equal groups, the dosed and control

*A heft of sheep is a part of a hirsel or flock, usually a few score, which has the exclusive grazing of a well-defined section of hill and which does not stray from that part of the hill.

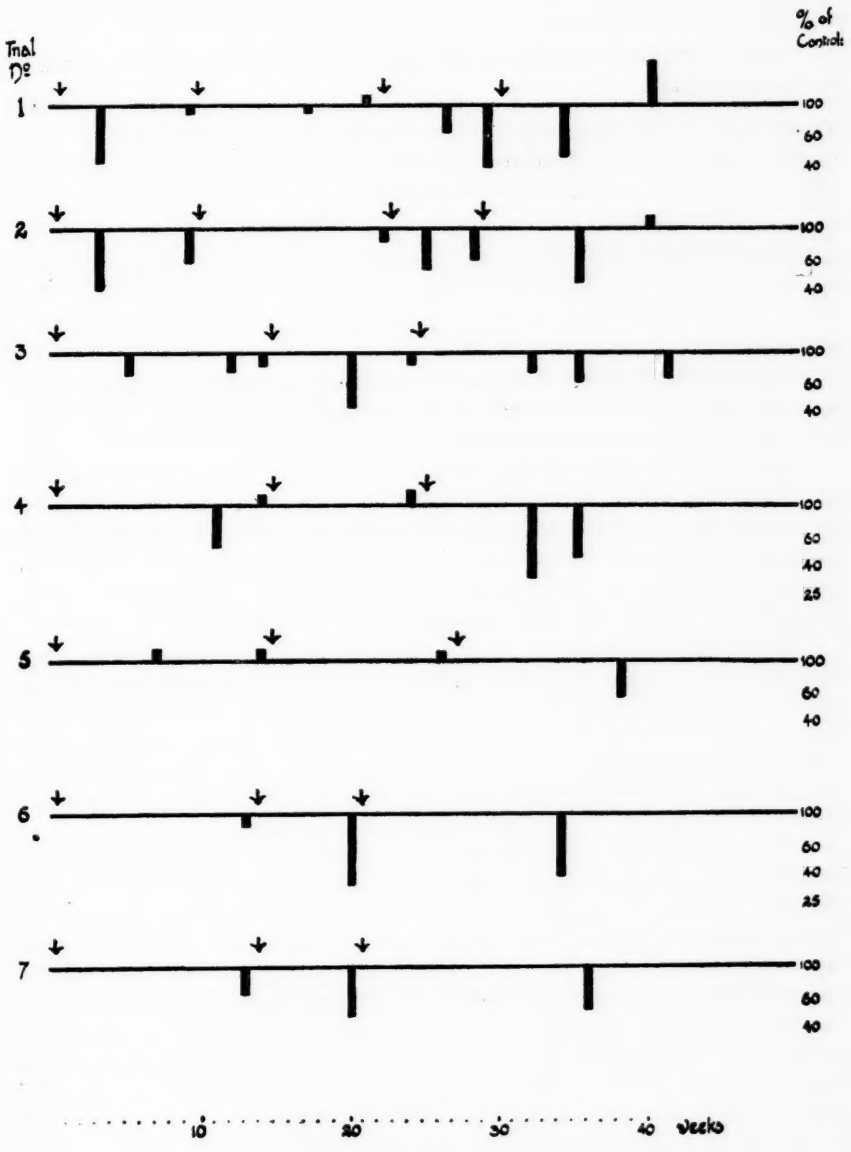

Fig. 1

Fig. 1 shows the average percentage differences of the transformed O.S. worm egg counts of the dosed hoggs compared with those of the undosed control hoggs.

groups were determined by drawing lots. The older sheep of the heft were not dosed.

Farms.

These trials were carried out on eight farms in the following localities of Southern Scotland.

Farm	*Locality*	*Breed*
A-C	near centre of Southern Uplands	Scottish Blackfaces
D	western end of Lammermuir Hills	" "
E	near Cheviot	Cheviots
F	in basin of Border Esk	"
G	western end of Cheviot Hills	Scottish Blackfaces X Cheviots
H	Pentland Hills	Scottish Blackfaces

Anthelmintics.

The initial trials were designed to determine the effect of phenothiazine on worm egg counts and on body and fleece weights when given once, twice, three and four times between autumn and spring.

The results of dosing during the last few days of March or the first few days of April are shown separately from those of dosing earlier in March, because the worm infestations of Scottish hill hoggs increase rapidly during March and, therefore, the difference of two or three weeks may be important. The earlier dosing was timed to be given before most outbreaks of "black scours" occur, but a few weeks after the infestations show signs of increasing.

In the trial on farm A in 1949-50 about 62 gm. phenothiazine were given in the autumn and 52 gm. in the spring. At all other times doses averaging slightly over 40 gm. phenothiazine were given, except for the early September doses in 1951 on farms D and E when the doses were about 30 gm., and in early April, 1952, on farm C when under 20 gm. were used. The phenothiazine was given as suspensions in water and the weights given included the dispersal agent. In the tables "P" indicates phenothiazine dosage.

The early trials of this series, and other anthelmintic dosing trials on hoggs in fields, showed that dosing with phenothiazine could result in increased body and fleece weights in hoggs. However, phenothiazine is not an ideal anthelmintic; apart from difficulties of dosing and other objections, which have been discussed by Parnell, *et al.*, (1955), it does not remove *Fasciola hepatica,* which in many hill sheep is a parasite of considerable pathogenic importance.

For this reason in 1952-53, in addition to phenothiazine, a proprietary preparation, containing 20 per cent carbon tetrachloride, was used, and is shown in the tables as "CCl_4." The carbon tetrachloride preparation was not tried before January, as only on farms where fluke infestations were very severe would infestations be heavy much earlier in the lives of hoggs.

A proprietary nicotine sulphate and copper sulphate preparation, described in this paper as nicotine-copper sulphate or as "N. C.," was also included. It contains approximately 1.0 per cent of nicotine sulphate and 1.6 per cent of copper sulphate, when diluted. This preparation had shown promise when given

to hoggs wintered on fields and, therefore, trials were designed to see whether this anthelmintic could take the place of one phenothiazine dosing.

An average of between 15 c.c. and 16 c.c. of carbon tetrachloride preparation and of about 36-40 c.c. nicotine-copper sulphate was used.

Dates of Dosing.

In these tables the dates of drenching are shown by the following numerals: 1—September; 2—October; 3—November; 4—January or early February; 5—early March, and 6—late March and early April.

Data used.

In most of the series, insufficient trials have been carried out to establish which programmes should prove most satisfactory in practice, but the trials show that, even with the existing data, dosing can be of great value.

The effects of these anthelmintic treatments were tested by body weight and, in most trials, by fleece weight comparisons, the two "yardsticks" of practical importance. Worm egg counts were made at the time of dosing and several weeks later. The fæces of some of the dosed and control hoggs were cultured, and the larvæ from them identified and counted, to determine whether dosing altered the proportions of the different species parasitising the hoggs. No observations were made on the death rates of the dosed and of the control hoggs.

Results

Body and Fleece Weights.

The results of the dosing trials on the body and fleece weights are shown in Table I—hoggs on different hefts—and Table II—hoggs on one helf. Only phenothiazine was used in the trials which are detailed in Table I.

Table I

Body weight and fleece weight differences between hoggs dosed with phenothiazine and the undosed hoggs in trials in which the dosed and the undosed sheep were on different hefts.

Farm	Year	Dates of dosing, (see text)	Body weight gain in lb. Autumn to early spring	Autumn to June	Fleece weight gain in oz.
A	1949-50	2. 6.	-	(5.7)	(9.5)
A	1950-51	2. 6.	0.1	-0.2	8.0
B	1950-51	2. 6.	0.5	-2.0	-
C	1950-51	3. 6.	-	(4.3)	-
B	1951-52	2. 6.	1.2	3.4	4.6
C	1951-52	2. 6.	-	12.1*	-
E	1951-52	2.4.6.	1.3	6.3	-4.4
A	1952	6.	-	3.5*	0

The gains are the difference "Dosed minus Control", corrected for the difference in initial weights, except the gains shown in brackets, which are uncorrected differences because the hoggs were not weighed at the start of the trial.

*Difference in June since early spring.

This series of trials suffers from the disadvantages which are listed in the appendix.

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The details of the statistical analyses used in Table II are given in the appendix. Most of the gains in the individual trials were not statistically significant, but nearly all were positive, and over all the tests there was statistically a gain of body and fleece weights after dosing.

Table II

Effect of dosing on body weight and fleece weight in the One-heft trials.

Trial	Farm	Year	Times of dosing, (see text)	Anthelmintics used.	Gain in body weight (lb.) Autumn to March or April	Autumn to June	Gain in fleece weight (oz.)
1	E	1951-52	1.3.4.6.	All P.	0.8 ± 1.5	2.1 ± 1.8	2.6 ± 4.7
2a	D	"	"	"	4.7 ± 2.3*	4.4 ± 2.7	4.1 ± 7.1
b	"	"	"	"	3.6 ± 2.2	10.8 ± 2.4*	1.7 ± 6.5
c	"	"	"	"	2.4 ± 1.7	5.9 ± 2.0**	1.9 ± 5.2
3	E	1952-53	2.4.6.	"	2.2 ± 1.6	3.8 ± 1.8*	-0.8 ± 4.7
4	"	"	"	N.C.,CCl_4,P.	4.2 ± 1.6*	6.4 ± 1.8**	5.5 ± 4.9
5	H	"	"	N.C.,P.,P.	2.2 ± 1.6	2.3 ± 2.0	13.3 ± 5.1*
6a	F	"	2.4.5.	All P.	2.5 ± 1.4	3.3 ± 1.6*	10.1 ± 4.0*
b	"	"	"	N.C.,P.,CCl_4.	1.0 ± 1.4	0.3 ± 1.7	7.3 ± 4.3
7a	G	"	"	P., P.,N.C.	-	3.1 ± 1.8	6.5 ± 4.7
b	"	"	"	N.C.,CCl_4,P.	-0.6 ± 1.5	1.4 ± 1.7	1.2 ± 4.6
Overall average					2.04 ± 0.51**	3.56 ± 0.56**	5.24 ± 1.47**
Means of 4-dose trials					2.38	5.22	2.46
" " 3-dose "					1.89	2.93	6.29

* Significant at 1 in 20 level of probability.

** " " 1 in 100 " " "

The four-dose trials gave on the average a larger gain in body weight and less gain in fleece weight than the three-dose trials, but none of these differences was significant.

Among the three-dose trials, phenothiazine was used in the autumn in three and N.C. in the other four. There was no significant difference in the gain from dosing, resulting from the use of phenothiazine compared to N.C.

Over all the trials there was an average gain, resulting from effects of the dosing, of some 2 lb. to April and $3\frac{1}{2}$ lb. to June, in body weight, together with 5 oz. in fleece weight. The real value of dosing a full heft might be greater than these gains suggest (and perhaps much greater), in view of the probable effects of ground contamination.

The analysis makes it clear that the experiments were carried out on too small a scale to show up any differences in gain resulting from the different treatments. The relation of size of experiment to standard error is discussed in the appendix.

In many of the trials the hoggs were also weighed in early winter. By then in two out of four of the trials in which the dosed and the control hoggs were on different hefts, the dosed hoggs had lost less weight than the controls; and, when the dosed and the control hoggs were running together, in nine out of twelve trials the dosed hoggs had lost less weight.

Table III shows the serious drop in weight which occurs in dosed and undosed hoggs wintered on the hill, and the rapid recovery which takes place in spring and early summer, if the check has not been too serious.

Ten months after the end of a dosing trial on farm E, the average weight of the gimmers, which had been dosed as hoggs, was still 4.2 lb. heavier than

Table III

The average body weights in lb. of the dosed and of the undosed hoggs in each series of trials, in the autumn (at the start of the trials), in January or early February, in March or early April, and at the end of the trials (in June, July or August), and their average fleece weights in lb.

Farms	Anthelmintics	Dosing dates (see text)	Number of trials	Number of Dosed hoggs	Autumn Dosed	Autumn Controls	Early winter Dosed	Early winter Controls	March or early April Dosed	March or early April Controls	End of trials Dosed	End of trials Controls	Fleece weights Dosed	Fleece weights Controls
A	P.	6.	1	30	-	-	-	-	55.5	56.1	87.2	80.4	4.38	4.25
A, B, C	P.	P. 2. 6.	6	115	62.7	64.1	59.1	60.8	51.9	52.4	82.3	81.3	5.04	4.61
E	P. P. P.	2. 4. 6.	1	27	54.0	54.1	63.7	59.9	54.4	53.7	86.2[a] 82.2	74.0[a] 78.8	3.31	3.69
E	P. P. P.	2. 4. 6.	1	17	63.4	63.7	61.4	62.2	63.7	61.9	90.9	87.4	4.12	4.12
F	P. P. P.	2. 4.5.	1	21	61.5	61.9	53.7	52.8	48.3	46.1	65.2	61.2	4.97	4.12
G	P. P. N.C.	2. 4.5.	1	17	62.7	61.9	55.8	57.6	48.9	50.3	75.4	71.6	4.25	4.75
D, E	P. P. P.	P. 1. 3. 4. 6.	4	47	61.4	61.4	61.9	60.6	59.3	56.6	81.8	75.9	4.32	4.12
H	N.C. P.	P. 2. 4. 6.	2	32	68.8	69.3	67.7	68.0	63.7	62.3	87.6	83.3	4.85	4.25
F	N.C. P. OCl_4.	2. 4. 6.	1	21	61.1	61.9	53.1	52.9	46.2	46.1	61.0	61.9	4.75	4.12
H, G	N.C. OCl_4 P.	2. 4. 6.	2	32	62.1	61.1	56.8	55.7	54.4	52.0	82.8	78.4	3.84	3.60

[a] Not weighed earlier in trials

In the series above the line the dosed and the control hoggs were on separate hefts, and in the trials below the line the dosed and the control hoggs were on the same hefts.

those which has been the undosed controls. Plans for more observations on gimmers and ewes, which had been dosed as hoggs, were abandoned when the grant for this work was terminated. Brownlie (1954) has shown that, after a hogg-wintering trial, a " weight difference present when the sheep were 18 months old remained at $2\frac{1}{2}$ years."

Worm Egg Counts.

Figure 1 summarises the data on " Other Strongyle " egg counts from the one-heft trials. The horizontal scale gives weeks from the first dozing and arrows indicate times of dozing. Vertical bars show the differences between dosed and control hoggs at each counting, in percentage units on a logarithmic scale. When the dosed group has a lower average count than the control group, the bar extends downwards. Transformed egg counts have been used (see Appendix to Parnell *et al.*, 1955).

The intervals between counts were rather variable and often long, owing to hill conditions, and this makes interpretation of the results rather difficult. Probably the immediate effects of each dosing were greater than shown by the first count after dosing, which was taken several weeks later.

The histogram shows that the series of doses on each farm generally kept the "Other Strongyle" egg counts substantially below the level of the controls. The autumn dosing effects tended to disappear within about ten weeks, but more lasting effects generally followed the spring dose. The data, however, are not sufficient to show whether these lasting effects are entirely attributable to the spring dose alone, or depend in part on previous dosing.

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Most of the counts of the eggs of *Strongyloides* spp. and of *Nematodirus* spp. were very low both in the control and in the dosed hoggs, and do not justify detailed consideration.

Dosing with phenothiazine in the autumn still showed some effect on the Other Strongyle egg counts in January, but had been lost by spring; however, when the hoggs were also dosed in winter, the reduced worm egg counts persisted until the spring dosing, the effect of which also lasted for a few months.

Any effect on the O.S. egg counts of dosing with N.C. in autumn had been lost by January, but one trial suggested that the effect of dosing in spring might last longer.

In the few trials in which CCl_4 was used, the average O.S. egg counts of the dosed hoggs were somewhat lower than those of the undosed hoggs two or three months after dosing.

On farm C, minerals were available on a third heft from early in 1951. In April the average O.S. egg count of the hoggs on this heft was 666 e.p.g., which was almost the same as that of the controls, and 18 weeks later it was 413 e.p.g., which was under half that of the controls; these hoggs averaged over 3 lb. lighter than the dosed hoggs, but 10 oz. more than the controls. In 1951-52, however, the O.S. egg counts of the hoggs were higher on this heft than on either the dosed or the control hefts; at the end of the trial the hoggs averaged about 8 lb. lighter than the dosed hoggs, but were over 8 lb. heavier than those of the undosed control heft.

Larval Counts.

Table IV shows the average percentages of the larvæ of the Other Strongyles, which were recovered from the cultures of fæces of undosed hoggs and of hoggs after they had been dozed with phenothiazine. Insufficient cultures could be

Table IV

Average percentages of the larvae of the different genera of Other Strongyles recovered from the cultured faeces of undosed hoggs and of hoggs which had been dosed with phenothiazine in the autumn, winter and spring.

Genera	Average percentages of larvae recovered in period following dosing in:- Autumn Controls	Autumn Dosed	Winter Controls	Winter Dosed	Spring Controls	Spring Dosed
Ostertagia spp.	43	56	57	53	65	59
Trichostrongylus spp.	46	39	15	24	10	14
H. contortus	2	1	2	3	18	14
B. trigonocephalum	3	1	1	1	1	1
C. ovina	1	1	4	7	2	2
O. venulosum	5	2	21	12	4	10

counted following dosing with carbon tetrachloride preparation or N.C. anthelmintic to justify their inclusion, as, unfortunately, these observations were ended before the larvæ from some of the farms had been identified and counted.

In Table IV the average percentages of the larvæ are divided into three periods—those found subsequent to the autumn dosing and up to the time of the winter dosing; in this period the fæces were collected one to three months after dosing; following the winter dosing until the spring dosing, the fæces were

collected one to two months after dosing; and after the spring dosing, when the fæces were collected two to five months later. This table suggests that the worm burdens, which were built up after dosing, were similar in their proportions to those carried by undosed hoggs.

The percentages of larvæ of *Cooperia* spp. are not included in this table, as they were found in only two out of 58 samples, both following dosing.

Discussion

These preliminary trials show that anthelmintic dosing of hoggs wintered on the hill can significantly increase their body and fleece weights.

Unfortunately, insufficient trials were completed to determine definitely which of the three anthelmintics gave the best results in autumn, in early winter, and in late winter or early spring.

As the hoggs, which are wintered on the hill, are practically always intended for stock sheep, their sound wintering is even more important than the value of the few pounds of extra weight, which these trials show can be gained. In the trials, in which the dosed and the control hoggs were on the same hefts, the average live weight gain was about $3\frac{1}{2}$ lb. per head. It is probable that these gains are not the maximum obtainable. The timing of the dosings may not have been the best, and Gordon (1953*a*) has shown that phenothiazine can check the weight gain of sheep for over a month; it has been suggested (Parnell *et. al.*, 1955) that this happens when Scottish hill lambs are dosed with phenothiazine. Weight losses may have occurred in these hoggs after they were dosed, but the reductions of the worm burdens may have done so much good that any loss from the effect of phenothiazine may have been masked.

It is possible that some of the benefit from N.C. was caused by making good a slight copper deficiency, but trials on hoggs wintered " in-bye " on one farm suggest that this is not the case.

Although fleece weights are influenced by many factors, they are a valuable guide as they can reflect the complete year's history of the sheep, if a check in winter or early spring, followed by an improvement in condition, has not led to the fleece being cast; this happens more frequently in Cheviot than in Blackface sheep. Genetical factors have a very marked influence on fleece weights; therefore, fleece weights are most likely to be an accurate measurement when a heft or hefts are divided into equal groups, as then each group will be a random sample of the daughters of the same sires.

In most of the trials the average weight of the fleece from the dosed hoggs was heavier than that from the undosed controls. The over-all average increase of the trials in which the dosed and control hoggs were together was slightly over 5 oz., or more than 6 per cent, and in the other series of trials the average gain was about an ounce less, but in most of the trials the hoggs were dosed only twice.

In an earlier paper (Parnell *et. al.*, 1955) on dosing hill lambs it was shown that, when lambs were dosed with phenothiazine in late June or early July the decrease in worm-egg counts was not maintained beyond one or two months, but if the lambs were drenched in early August the difference in the worm egg counts

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lasted slightly longer. The results reported in this paper suggest that when hoggs are dosed in October the worm egg counts of the dosed hoggs remain lower than those of the controls for two or three months, and that when they are dosed in March or April the effect is evident for a longer period.

Observations on the levels and the sequence of the helminth infestations of Scottish hill hoggs have suggested that it is unlikely that anthelmintic dosing more often than once every two months at the most would be sound practice. It seems probable that the most vital treatments are in winter or early spring, but the cumulative effect of successive doses may be important.

It is desirable that anthelmintic dosings of hill sheep should not necessitate extra gatherings. In late summer or early autumn, drenchings can coincide with gatherings for dipping or for sales. About the middle of November, where the hoggs are wintered on the hill, they are gathered for "breeking,"* and early in January to take them off; in mid-March the hoggs are often gathered for vaccination, and in late March or early April all the sheep are usually gathered for dipping, and the gimmers and ewes for udder-locking and vaccination. Hoggs during winter can, however, usually be gathered fairly easily without bringing in many of the older sheep.

In southern Scotland a large number of hoggs are wintered on the hill, but on most farms north of the Forth the hoggs are wintered on low ground farms. Anthelmintic dosing trials on hoggs wintered on the fields of hill farms show that their body weights can be increased by several pounds and their fleece weights by a few ounces. It would be surprising, therefore, if drenching could not increase the body and fleece weights of hoggs wintered away, although they are usually put on to fairly clean ground. It will, therefore probably be found that it is sound practice to dose them just before they leave the hill farm, and that there may be then a long interval before the next treatment, unless they are carrying heavy infestations of immature stages when they leave the hill farm.

The benefit of strategic dosing has been shown in practice, where the prevention of "black scours" is all important, to reduce the late winter death-rate, and to reduce the number of hoggs which have wintered so badly that they cannot be kept as stock hill sheep.

One farmer, who for several years had dosed his hoggs and on whose farms much research work has been done, now keeps between thirty and forty fewer hoggs to provide the same number of stock ewes as was formerly required.

On a hill farm, on which a severe outbreak of "black scours" occurred in 1947, with heavy infestations of *Ostertagia* spp. and of *Trichostrongylus* spp., regular dosing of all sheep was begun in 1948. The Blackface gimmers and ewes, unlike the Cheviots, were not dosed in late winter. Table V shows the death-rates, the lambing percentages and the average fleece weights in the three years before and the six years since dosing started. The farm now carries over six score more sheep than before dosing started. The marked increase in the average weights of the Cheviot fleeces was accounted for, at least partially, by a very

* A piece of cloth or sacking is sewn on the wool to cover the tail to prevent mating. On farms which have sufficient enclosed ground the hoggs are sometimes kept in the fields while the rams are on the hill.

marked decrease in the number of sheep which had shed their fleeces by clipping time. The increased lambing percentages can probably be accounted for by the fact that more young sheep became pregnant and were able to rear lambs. Davies (1954) has shown that when hoggs had been badly wintered some 20 per cent more may be barren as gimmers compared with those that had been well wintered.

Table V

The average death rates, lambing percentages and fleece weights in lb. before and after strategic dosing started on a hill farm in 1948. The winters of 1947 and 1951 were severe.

Year ending in	Average deathrates, Hogg,		Ewe and gimmer		Average lambing percentages,		Average fleece weight		
	Cheviot,	Blackface,	Cheviot,	Blackface	Cheviot,	Blackface.	Cheviot, hogg,	ewe.	Blackface.
1945	-	-	-	-	-	-	3.00	3.46	5.28
1946	6.7	9.0	3.5	3.9	74	80	3.84	4.09	5.39
1947	17.8	14.5	6.7	10.0	60	54	3.45	3.65	4.14
1948	12.0	3.2	2.8	2.5	71	78	3.69	3.70	4.49
1949	5.7	4.9	4.3	4.7	77	91	4.70	4.77	5.53
1950	2.0	8.5	5.5	3.2	78	88	4.42	4.17	5.39
1951	2.7	6.8	3.8	6.5	89	75	4.30	4.10	4.50
1952	3.9	2.1	5.1	3.7	81	79	3.94	4.11	4.57
1953	5.5	4.2	4.0	4.9	81	83	4.03	4.02	4.60
1954	4.5	6.3	4.0	3.7	77	82	4.81	3.72	4.19
Average before dosing*	11.9	9.1	4.4	5.5	68.2	71.3	3.47	3.73	4.95
Average after dosing	4.1	5.5	4.5	4.5	80.4	82.8	4.34	4.14	4.78†

*Comparable data were not available prior to the summer of 1945.
†For some years the tendency has been to breed lighter fleeced Blackface sheep.

Neither of these examples were controlled experiments and other factors may have influenced the results, but the most obvious change in management common to both farms was the institution of regular anthelmintic dosing.

These results, which were obtained from rather "hit or miss" dosing programmes, suggest the urgency for more trials to be undertaken, based on dosing all age groups when infestations are heaviest or most pathogenic. Until this is done, hill farmers throughout the British Isles cannot be given definite advice on times of dosing and choice of anthelmintic, in order that the present very large and unnecessary wastage of meat and wool can be reduced, and our imports of these products correspondingly cut. Undoubtedly similar improvements may not occur in all districts, but it would be surprising if hill farming could not be made more profitable with more strategic dosing.

In these trials no anthelmintic treatments were given to hoggs after early April; the effect of another dosing in May should also be tried, where it is practical; infestations are often very heavy then, but are probably less serious because grass is more plentiful.

No hogg dosing trials had been started in the Highlands, but a practical anthelmintic dosing programme for the West Coast and the Highlands is urgently needed, as profitable livestock farming should be one of the mainstays in the economy of these problem areas.

In the west and south-west of Scotland, where *Fasciola hepatica* and *B. trigonocephalum* may both be numerous, trials should include carbon tetra-

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chloride; although in the one trial in which this anthelmintic was given in the spring the result was not particularly encouraging; however, when it was given in early winter the results of the two trials were more promising.

For late winter and spring dosing an anthelmintic which is effective against the immature stages is required. Crofton's (1954) hypothesis that the larvæ which are ingested by low-ground ewes in the early winter may take longer to reach maturity, without remaining dormant in the mucosa, than those ingested nearer parturition, may have a parallel in hill hoggs, in which their low condition in late winter has a corresponding effect on the larvæ to that of parturition in older sheep. This suggests the necessity for dosing trials in late February and early March.

An efficient strategic dosing programme, to prevent losses from worms in late spring, should reduce some of the all too prevalent distress in hill sheep at that time.

Many more trials on hill-wintered hoggs are, therefore, called for, especially with alternations of anthelmintics.

Summary

Anthelmintic dosing trials were carried out on hill hoggs on two systems: (a) All the hoggs of a heft were dosed and those of another neighbouring heft were used as controls; (b) Half or a third of the hoggs of a heft were dosed and half or a third were left undosed as controls.

No significant difference was found between the effects of dosing three and four times, or between the effects of dosing with various alternative anthelmintics; but the standard errors of the individual trial estimates were high, and appreciable differences in the merits of the different dosing programmes cannot be ruled out.

The average net body weight gain from the three to four doses in the one-heft trials was 3.56 ± 0.56 lb., and the average fleece weight gain was 5.24 ± 1.47 oz.

Acknowledgments

Again we wish to thank the farmers, managers and shepherds, whose help and co-operation made these trials possible, and Em. Prof. J. Ritchie, C.B.E., Dr. D. O. Morgan and Prof. M. M. Swann for their help, while these observations were being made at the Department of Zoology of the University of Edinburgh.

We are most grateful to Dr. E. C. R. Reeve for his analyses of the statistical data and for having added an appendix to this paper, and to Dr. H. Paver, whose statistical analyses of our earlier trials proved most helpful in planning the later trials.

We wish to thank Messrs. Boots Cash Chemists Ltd. and Imperial Chemical (Pharmaceuticals) Ltd., who gave phenothiazine for these and other trials on hill sheep.

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Appendix

By E. C. R. REEVE*

Apart from variations in the dosing programmes, two types of dosing trials were carried out in this series, and their relative statistical merits will be discussed before the data are analysed. The two types differ as follows:

(a) one-heft trials: some of the hoggs on a heft or hefts were dosed and the rest of the same heft or hefts acted as controls;

(b) two-heft trials: all the hoggs on one heft were dosed and those of a neighbouring heft acted as controls.

In one-heft trials differences in weight, etc., at the start of the trial can be eliminated from the final comparisons, and a standard error calculated for the corrected measure of dosing effect; but the undosed sheep running with the dosed hoggs may reduce the total effect of dosing by contaminating the ground, so that one obtains an estimate whose sampling error is relatively small and can be ascertained, but which is subject to an unknown amount of bias. The extent of this bias could perhaps be estimated by comparing trials in which different proportions of the heft were dosed, since contamination would be at a maximum if few of the sheep were dosed and at a minimum if most of them were dosed. No data of this kind are yet available.

Two-heft trials do not enable one to distinguish between the effects of dosing and of environmental differences between the paired hefts, so that no sampling error can be calculated for individual trials. But a large series of such trials would give a completely unbiased measure of the effect of dosing. For this purpose it would be necessary to choose a number of pairs of hefts, the two of each pair being as alike as possible, and then to allocate at random which heft of each pair was to be dosed. Heft differences may well be large, in terms of nutritional effects, so that probably some 20-30 two-heft trials would be necessary to give a reasonable estimate of the value of a single hill-sheep dosing programme. A second year of trials on the same hefts, in which the dosed and undosed hefts were always interchanged, should add considerably to the statistical accuracy of the results, by enabling permanent, but not seasonal, heft differences to be eliminated from the comparisons.

These points have been raised here since the relative merits of a biased estimate having a low sampling variance (type (a) trials), and an unbiased estimate which costs more to obtain and is relatively inaccurate (type (b) trials) will have to be considered in any future work on hill sheep.

In the present case only a few preliminary (b) trials were carried out, and they provide insufficient comparisons for a sampling error to be estimated, since this must be based on differences in mean dosing effect from trial to trial. Moreover, because other observations were being made, the decision as to which heft of a pair was to be dosed was not made strictly at random, and when a test was repeated the following year the dosed and control hefts were not interchanged, so that we cannot assume that the comparisons are unbiased. In the type (b) trials,

* Member of the scientific staff of the Agricultural Research Council.

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therefore, the final estimates have simply been corrected for differences in the means at the start of each trial, since this probably improves their accuracy.

The rest of this appendix will be confined to the type (a) trials.

Body Weight and Fleece Weight.

Difference in mean body weight between the dosed and control groups, at the start of a trial in the autumn, will influence the final comparisons, and their

Table VI

Regressions of April and June body weights and fleece weight on Autumn body weight.

	Regressions on autumn body weight	Corresponding correlation coefficients
April weight	0.72 ± 0.07 lb. per lb.	0.671
June weight	0.93 ± 0.08 lb. per lb.	0.711
Fleece weight	0.64 ± 0.02 oz. per lb.	0.317

These regression coefficients were used in correcting for initial weight difference.

effects must be eliminated by multiplying each difference by the regression of final on initial weight and subtracting the result from the final difference (see appendix to Parnell, Dunn, Mackintosh and Reeve, 1955). Fleece weight can be corrected in the same way, since it is correlated with initial body weight. Estimates of the regression coefficients were obtained from the 142 control hoggs which were individually numbered. They were distributed on eight hefts, so that the differences in regression between hefts could be tested. These proved statistically insignificant, and Table VI gives the average regression coefficients with their standard errors, together with the corresponding correlation coefficients.

The standard errors are calculated as described previously (Appendix *loc. cit.*) using the appropriate correlation coefficients (r) from Table VI and an estimate V of the sampling variance within hefts and treatments. This variance was sufficiently consistent from heft to heft for a pooled estimate to be used, and Table VII shows the average variance within hefts, for the control and the dosed

Table VII

Average variances within hefts: Body and Fleece weights.

	Body weight, lb.			Fleece weight, oz.	Degrees of freedom.
	Autumn,	April,	June		
Controls	38.5	34.6	54.6	182	123
Dosed	41.6	37.4	50.0	220	149
Average	40.0	36.0	52.3	201	

hoggs, of body weight and of fleece weight. There is little difference between the averages of dosed and control groups, and the over-all averages have been used in calculating the standard errors of the adjusted mean differences by the usual formula :

S.E. = square root of ($[1-r^2]$ $[1/c + 1/d]$ V), where c and d are the numbers of the control and of the dosed hoggs in the trial.

Table II gives the corrected mean body weight differences in April and in June, and the fleece weight differences, attributable to dosing, with their standard errors, for each trial.

A majority of the individual gains were not statistically significant, but almost all were positive, so that the mean gains over all trials were highly

Table VIII

Mean dosage effects and heterogeneity.

	April weight		June weight		Fleece weight	
	DF.*	χ^2	DF.	χ^2	DF.	χ^2
Overall mean	1	15.8	1	39.9	1	12.7
4 versus 3 doses	1	0.2	1	3.3	1	1.5
Heterogeneity	8	7.9	9	16.1	9	6.5

* DF. = degrees of freedom 1 in 20 Significance levels (DF. = 1 8 9; χ^2 = 3.84, 15.5, 16.9)

significant. The high standard errors for individual trials, which result from the rather small samples used, make it unlikely that significant differences between treatments would be found, but it is worth testing for the difference between three and four doses, and for heterogeneity between trials. Table II shows that the four-dose trials gave a greater average gain in body weight, but less in fleece weight, than the three-dose trials, but there was considerable variation in gain, ranging from 0 to 11 lb. for June weight, and from —0.8 to 13 oz. in fleece weight. To test these effects, each trial mean is weighted by the reciprocal of its squared standard error and the resulting variate treated as approximately a χ^2 variate (see Appendix to Parnell, *et al.*, 1955). The analysis is given in Table VIII.

Only the over-all mean effect is clearly significant, and there is no definite evidence that the four-dose trials give a greater weight gain than the three-dose trials. There is possibly some sign of heterogeneity between trials in the full gain from autumn until June, but not in gain to April or in fleece weight gain. It may be remarked that some heterogeneity between even one-heft trials is to be expected, since variations in worm burden from farm to farm are bound to come variations in the gain from dosing.

Among the three-dose trials, we may compare the three trials using phenothiazine with the four using N.C. in the autumn, although the winter and spring doses were also varied to some extent. The June weight gains averaged 3.5 lb. for the phenothiazine series and 2.6 lb. for the N.C. series, so that the mean difference is 0.9 ± 1.3 lb. Clearly this is insufficient reason for concluding that the use of phenothiazine rather than N.C. in the autumn gives any advantage.

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Summarising these results, it can be said that three to four doses cause an average gain of between 1 and 3 lb. in body weight up to April, an average gain of between 2.5 and 4.5 lb. up to June, and a gain of between 2.3 and 8.2 oz. in fleece weight. These figures are based on 5 per cent fiducial limits, and make it clear that a larger series of trials, with larger samples, would be needed to give accurate estimates of the gain to be expected from any dosing programme.

From Tables VI and VII it appears that in a single one-heft trial, in which n dosed hoggs were compared with n undosed hoggs, the gain in body weight from autumn to June, corrected for weight differences in the autumn, would have a standard error of about $7/\sqrt{n}$, so that about 50 dosed and 50 control sheep would be needed to give a standard error of 1 lb. This number is rather large because of the considerable range of body weights of the hoggs on the hefts studied.

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THE POTENCY OF ANTI-ANTHRAX SERUM

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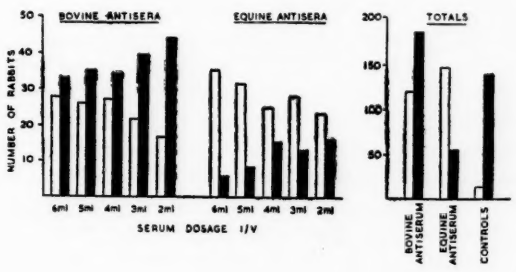
An effective method of standardising the potency of anti-anthrax serum has not yet been devised. Its power to confer a passive immunity on susceptible animals can be demonstrated readily by tests such as Sobernheim's in which graded doses of antiserum are given intravenously to rabbits followed immediately by the inoculation of virulent anthrax culture. In this type of test, though the passive immunity conferred by the antiserum is usually clearly marked in the animals inoculated with it, the results of individual tests are often erratic in so far that the degree of protection afforded does not appear to bear a direct relation to the dose of antiserum. Thus, when testing a batch by this method, rabbits given the larger amounts of antiserum may die after challenge while those receiving the smaller amounts survive; on repetition, the reverse may well occur. Variation in susceptibility on the part of the test animals would appear to be the reason; indeed, some rabbits encountered in the course of this work appeared to have a high degree of natural resistance to infection with *B. anthracis*.

A number of batches of anti-anthrax serum prepared at this laboratory from blood of hyperimmunised cattle and horses have been tested by a method similar to that of Sobernheim and the results of 101 such tests have been summarised and are set out in the table and diagram below. Both species of animals from which the antiserum was derived were hyperimmunised by exactly the same procedure. Sixty-one batches of bovine antiserum and forty batches of equine antiserum were tested in a total of 658 rabbits, this number including 153 control

FIG. 1



The white columns indicate the number of rabbits remaining alive fourteen days after inoculation with virulent B. anthracis. The black columns indicate the number which died of anthrax during that period.

animals which received no antiserum; all were between 2 kg. and 3 kg. in weight and of mixed breeds. Many of these batches were tested two at a time, one bovine and one equine serum, using five rabbits for each batch and two controls. In some early tests, control groups were included which were given normal bovine

and equine sera but as there was no evidence on any occasion of non-specific immunity being conferred by them, the practice was abandoned and no reference is made to these in the figures quoted. The five rabbits received the antiserum intravenously in graded doses ranging from 2 ml. to 6 ml. and, approximately

TABLE 1

Batches of Antisera	Serum Dosage i/v 6ml	5ml	4ml	3ml	2ml	Totals	Controls (No serum)
Bovine Antisera	28/33	26/35	27/34	22/39	17/44	120/185	
(61 batches)	(45.9)	(42.6)	(44.3)	(36.1)	(27.9)	(39.3)	13/140
Equine Antisera	35/5	32/8	25/15	28/12	24/16	144/56	(8.5)
(40 batches)	(87.5)	(80.0)	(62.5)	(70.0)	(60.0)	(72.0)	

NOTE: The numerator indicates the number of rabbits remaining alive fourteen days after inoculation with virulent B. anthracis, the denominator the number which died of anthrax during that period. The figures in parentheses indicate the survivors in rate per cent. of the total in that group.

fifteen minutes later, these with two control animals were inoculated intramuscularly with 100/1,000 M.L.D. of an anthrax culture virulent for rabbits. The results of the tests on the 101 batches have been aggregated and are set out above, the only differentiation made being that between the animals which died within fourteen days of inoculation and those which survived this period. Many of the rabbits which died of anthrax, though given antiserum, took an appreciably longer time to succumb than the control animals and it would seem now that the measurement of this time might have proved a less crude method of assessing potency.

Discussion

It will be seen that of 305 rabbits inoculated with bovine antiserum, 120 (39.3 per cent) survived and 185 (60.7 per cent) died of anthrax after challenge; of 200 rabbits inoculated with equine antiserum, 144 (72.0 per cent) survived and 56 (28.0 per cent) died; of 153 controls which received no antiserum, 13 (8.5 per cent) survived and 140 (91.5 per cent) died.

The apparent lack of correlation between the dose of antiserum given and the degree of protection conferred, as frequently observed in individual tests, largely disappears when reference is made to a sufficient number of tests. It will be seen that the number of survivors in the groups treated with bovine antiserum fell more or less gradually from 45.9 per cent of those given 6 ml. to 27.9 per cent of those receiving only 2 ml. The corresponding figures for the equine antiserum were 87.5 per cent falling to 60.0 per cent.

The main point of interest which emerges from these figures is that as far as rabbits as test animals are concerned, anti-anthrax serum derived from horses would seem to be much superior to that of oxen in its capacity to confer passive protection. Yet there is no reason to believe that equine antiserum is more effective than bovine antiserum when treating the disease in cattle under field conditions; in fact, the contrary would appear to be the case, as perhaps one might expect. Hudson (1955) reported that to produce the same therapeutic effect when treating infected cattle in field outbreaks in Northamptonshire, twice as much equine antiserum as bovine antiserum had to be used. It may be,

therefore, that the testing of batches of anti-anthrax sera in small laboratory animals is of little value in assessing their true potencies for other species. The substitution of guinea-pigs for rabbits might produce equally misleading results.

A number of investigators (Cromartie, *et al.*, 1947; Watson, *et al.*, 1947; and Evans and Shoesmith, 1954) have shown that a tissue-damaging factor is associated with *B. anthracis,* and Smith, *et al.* (1954) have isolated a specific lethal factor from the plasma of animals dying of anthrax. It is probable that as more becomes known about the cause of death in anthrax infections, the exact means by which anti-anthrax serum exerts its protective effect *in vivo* may be clarified and a more accurate method of testing for potency be devised.

Summary

The results of 101 potency tests carried out in rabbits on batches of anti-anthrax serum derived from hyperimmunised horses and cattle are summarised. Equine antiserum was about twice as effective as bovine antiserum in protecting these animals passively though from field experience it would appear that the homologous type gives better therapeutic results when treating infected cattle in natural outbreaks of the disease. It is suggested that this form of potency test in small laboratory animals is unsatisfactory for anti-anthrax sera intended for use in other species.

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AN APPRECIATION

Professor DENNY HAMMOND UDALL

1874-1955

PROFESSOR UDALL died in his sleep on the night of September 8 from a coronary embolism. He had been in apparent good health up to the day of his death. He had put in a full day in his office where he was working on a revision of his book, "The Practice of Veterinary Medicine," of which the sixth edition appeared in 1954. Although he retired in 1942 from active service as Professor of Veterinary Medicine, Head of the Department of Veterinary Medicine, and Director of the Ambulatory Clinic in the New York State Veterinary College, Cornell University, he came to his office each day as regularly and perhaps a little more punctually than many of his colleagues who have not yet reached that coveted Professor-emeritus title.

Udall was born and raised on a farm in the State of Vermont. He graduated from the University of Vermont in 1898 with the degree B.S.A. (Bachelor of Science in Agriculture). In 1938, in recognition of his distinguished career the University honoured him by granting him the honorary degree, D.Sc.

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(Doctor of Science). He came to Cornell in 1898 to pursue the study of veterinary medicine and was granted the D.V.M. degree in 1901.

He was in private practice in his native state for two years. He then began his long teaching career as Assistant Professor of Surgery in the Veterinary School of Ohio State University. In 1908 he was invited to become Professor and Head of the Department of Medicine at Cornell, a position which he held for 34 years. He became the Director of the Ambulatory Clinic when it was established in 1914. Through Udall's unflagging efforts this clinic grew rapidly until it became the largest in America. When the publication, "The Cornell Veterinarian," was established in 1911, Udall was one of the editors. In 1918 he became editor-in-chief, a position which he held for 20 years. During most of this time he not only edited the publication but served as its business manager, circulation manager, publisher and office boy. Even though he received no remuneration for his efforts, except the approbation of his colleagues, he worked unremittingly to make it a worthy outlet for high quality research papers on animal health and disease.

Udall twice responded to the call of his country in time of war. He was a private in the Spanish-American War, and a major in the first World War. In the latter he was a member of the Expeditionary Force which went to France, being the Division Veterinarian of the 86th Division. He was an intense patriot and was always proud of his military service.

Udall was a rather hard taskmaster for himself and for his students. He insisted on accuracy in all matters and was not inclined to accept excuses from his subordinates. He had a sharp wit and a flair for sarcasm before which his students were apt to quail, but they respected him. After they had graduated almost all his former students held him in high regard and esteem. They all enjoyed recalling incidents in which they or their classmates fell foul of his eccentricities.

The private veterinary practitioners of America never had a better champion than Dr. Udall. On many occasions, particularly in the early days of the campaign for eradicating bovine tuberculosis, he fought those who would hire full-time veterinarians for such work, arguing that the work could be done better and more economically by the employment, on a part-time basis, of local practitioners, each of whom would deal with these problems so far as it concerned his regular clientele. This scheme has worked very satisfactorily so far as the government work is concerned, it has had a tremendous advantage in that it kept local practitioners in areas where they could not have stayed otherwise.

Denny Hammond Udall not only was a great teacher and clinician but he was a cultured and well-read gentleman. His portrait in oils hangs in the library of the Veterinary College. It is a tribute of the alumni—his former students. His mortal remains lie, close to Ithaca, in the same cemetery near those of his revered teachers, James Law and Walter L. Williams.

WILLIAM A. HAGAN,
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REVIEWS

THE CALF: ITS MANAGEMENT, FEEDING AND HEALTH, by J. H. B. Roy. London: Farmer & Stock-Breeder Publications, Ltd. 79 pages. Price 5s.

THIS is an extremely useful little book, dealing in a practical manner with the management, feeding, housing and health of the calf. Mr. Roy is on the staff of the National Institute for Research in Dairying and we know from his researches that he is well qualified to write a book on this subject. He has covered in its 79 pages all aspects of the subject including care under parturition, detailed feeding requirements, diagrams of calf houses and information on diseases. Veterinary Surgeons are not likely to take exception to the information in the last chapter on Calf Diseases since there is no attempt at making this section into a "home treatment guide." Perhaps one can single out the section on feeding as being of particular merit.

RADIOISOTOPES IN BIOLOGY AND AGRICULTURE: PRINCIPLES AND PRACTICE, by C. L. Comar. McGraw-Hill Book Company, Inc. 481 pages. Price 67s. 6d.

To the uninitiated the science of radio-biology with its many dramatic facets conjures up a picture of material omnipotence and omniscience which points the way to the solution of all worldly problems. Some may suspect and reject the science because the problems it creates may be more fearsome than those which it solves, but the discerning worker recognises its true value as another and perhaps more sensitive tool in his general armamentarium. Any book, therefore, which is designed to demonstrate and explain the techniques required in the handling of this new aid to experimental work and demonstrates its application to research problems, must have its place on any scientific reference shelf. When the book bears the world-renowned name of C. L. Comar, of the Oak Ridge Institute of Nuclear Studios, as its author, its value is enhanced.

Although the subject matter is sufficiently advanced to require some considerable knowledge of chemistry, mathematics and biology for its understanding, the author presents, in a lucid manner the basic principles concerning the value of radio-active isotopes and the planning methods necessary when they are used in research. Throughout the ten chapters, sufficient detail is included to enable a biologist to extract the information he may require for all the various recognised techniques.

The first chapter deals with basic principles illustrated by examples drawn from such diverse fields as physiology, nutrition, entomology, soils and fertilisers. The second chapter covers many of the difficulties which may be encountered in tracer studies. The next chapter is devoted to health physics and the introduction of the various units and physical concepts necessary for work with radio-active materials. The remaining chapters deal with facilities and handling of isotopes, general procedure for radio-assay, properties and procedures applicable to individual radio-isotopes, autoradiography, paper chromatography, ion

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exchange and radio-activation analysis. The final chapters cover a glossary of selected terms in nuclear science, the availability of U.S. Atomic Energy Commission Reports and a summary of radio-isotope preparations available in the U.S.A. The book concludes with a valuable name index in addition to a subject index. There is a comprehensive list of cited references at the end of each section and where applicable, an additional list of general references.

The illustrations are excellent and the quality of printing and binding are very good. It can be said that this book is a valuable one for it brings together in one volume the necessary biological and chemical information for planning and carrying out radio-active isotope tracer studies.

STUDIES OF THE PSYCHOLOGY AND BEHAVIOUR OF CAPTIVE ANIMALS IN ZOOS AND CIRCUSES, by H. Hediger. London: Butterworth & Co. Price 30s. net, post 10d.

THIS book is of fascinating interest and provides information of a far wider nature than its title would suggest. It is the author's aim to present a study of animal psychology as seen in the captive and to some extent disciplined animal exemplified in the circus animal, but it is impossible to confine the subject within so narrow a compass. The result is that the reader is presented directly and indirectly with a mass of most interesting and illuminating information regarding animal behaviour, both when the animal is in its wild state and when it is brought into captivity and therefore close and daily contact with man. Let no one imagine that this is an abstruse and academic book. Scientific it is but Dr. Hediger is possessed of such a breadth of knowledge and has so great a gift of communicating it that it is indeed difficult to put his book down.

Take a few of his chapter headings. "How Animals Live," "The Animals' Daily Life," "The Animal and Its Enemies," "Animals Among Themselves," "Flight and Hypnosis," "Play and Training," and it will be seen what manner of book we have, and how full of interest it is. There is no other book containing anything like the volume and the diversity of information regarding animal behaviour which Dr. Hediger puts before his readers.

The book is fully documented and contains a bibliography covering five pages. The illustrations, though not many, are all instructive and illumine the text.

NEWS

VITAMIN E SUCCINATE IN VETERINARY PRACTICE

At the Third International Congress on Vitamin E held in Venice in September, special sessions were devoted to the veterinary uses of alpha tocopherol. Its value in the veterinary field was attested by Blaxter (Britain); Lambert (Eire); Ferrando (France); Usuelli and Piana (Italy); Dam, Prange, Sondergaard, Nielsen, Fisker and Pedersen (Denmark); and Safford, Swingle, Marsh, Krukovsky, Warner, Loosli, Willman, Scott and Norris (U.S.A.).

The curative effect of vitamin E in muscular dystrophy in young calves has been adequately proved by Blaxter, Sharman and others.

Lambert's paper featured the benefits conferred by VITA-E succinate in dogs and small animals by way of correcting reproductive disturbances, the "rejuvenation" of aged dogs and cats, and the improved performances on the track of racing greyhounds.

A comprehensive series of tests on horses has been carried out at one of the largest National Stud Farms in the world. The studies were divided into two sections: the first concerns mares and stallions and the second racehorses in training. The data on the breeding aspects are replete and are reported to reveal highly satisfactory findings. The results of the tests on racehorses which ran during the Flat Racing Season ending in November are being assembled. They will compare the performances of the horses that received vitamin E succinate with the best performances of the same horses during the preceding Season. Results to hand indicate that the completed report will confirm the value of vitamin E in the above fields. The General Manager of the Stud Farm in question expects to complete his full report by the end of December.

APPOINTMENT

Mr. A. P. Irwin has been appointed Sales Manager of the Animal Feed Department, Lederle Laboratories Division, Cyanamid Products Ltd. Mr. Irwin was previously Assistant Sales Manager, Lederle Laboratories Division, in charge of the marketing of Aurofac 2A (Aureomycin Feed Supplement): he joined the Company on April 25, 1955, having previously been Assistant Sales Manager, Cooper, McDougall and Robertson Ltd., Berkhamsted.

ITEM OF VETERINARY INTEREST

We have received from Messrs. Evans Medical Supplies Ltd. of Liverpool a copy of a brochure which was published at the time of the Veterinary Congress in Belfast. It contains a number of cave paintings which have been reproduced in

advertisements for veterinary products by this firm. The interest aroused was such that it was thought that many would like to have them assembled under one cover.

A copy will be gladly sent to any Veterinary Surgeon or Veterinary Student on request.

NOTICE

IMPERIAL CHEMICAL (Pharmaceuticals) LTD. wish to draw the attention of veterinary surgeons to the change in title of their product "Anavenol" K Solution. The new form of this well-known intravenous anæsthetic for large animals is now described simply as "Anavenol." "Anavenol" is available in bottles of 250 c.c. and is twice the strength of the original "Anavenol" K Suspension.

Publishers' Notices

THE BRITISH VETERINARY JOURNAL, with which is incorporated THE VETERINARY JOURNAL, is published monthly, and copy for advertisements should be in the hands of the advertisement manager not later than the 20th of the preceding month, if proof is required. Tel.: Temple Bar 3386.

Letters for the Journal, literary contributions, reports, notices, books for review, exchanges, new instruments or materials, and all matter for publication (except advertisements) should be addressed to the Editor.

Annual Subscription, 40s. ($6.50 U.S.A. currency, post free).

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